

WHAT IS CLAIMED IS:

1. A computer implemented diagnostic tool for automatically diagnosing a system
- 2 by:
- 3 determining a path in the storage system to test, wherein the path includes path
- 4 components including at least a host adaptor, a link, a device interface, and a device;
- 5 performing an initial test to determine if there is a failure in the path;
- 6 adding at least one of the path components to a suspect list capable of being a cause of
- 7 the failure, wherein the suspect list is implemented in a computer readable data structure;
- 8 performing at least one isolation test on at least one of the path components added to
- 9 the suspect list;
- 10 removing the tested path component from the suspect list if the isolation test confirms
- 11 that the tested path component cannot be a source of the failure; and
- 12 returning the suspect list to a user to provide information on the path components
- 13 capable of being the cause of the failure.
2. The method of claim 1, wherein the initial test comprises a test of the path, and
- 2 wherein path components are added to the suspect list and isolation tested after the initial test
- 3 indicates a path failure.
3. The method of claim 1, wherein the initial test comprises a test of the path, and
- 2 wherein path components are added to the suspect list and isolation tested after the initial test
- 3 indicates no path failure to provide additional testing of the path components.
4. The method of claim 1, wherein isolation testing the host adaptor comprises:
- 2 generating output to instruct the user to disconnect the host adaptor from the link,
- 3 wherein the isolation test is performed on the host adaptor after the user provides input

0972666-03001

Pub 11

Pub #1

4 indicating that the host adaptor was disconnected, wherein the host adaptor is removed from  
5 the suspect list if the host adaptor passes the diagnostic test.

1 5. The method of claim 4, further comprising:  
2 generating output to instruct the user to replace the link if the host adaptor passes the  
3 test;  
4 performing a link isolation test on the path with the new link; and  
5 removing path components from the suspect list if the link isolation test on the replaced  
6 link indicates that the link was one cause of the failure.

1 6. The method of claim 5, wherein if the link isolation test indicates that the link is  
2 not one cause of the failure, further performing:  
3 removing the link from the suspect list;  
4 generating output to instruct the user to reinstall the previously replaced link; and  
5 performing a device interface isolation test of the device interface.

1 7. The method of claim 6, further comprising:  
2 generating output to instruct the user to disconnect the device interface from the link to  
3 allow for isolation testing of the device interface.

1 8. The method of claim 6, wherein if the device interface isolation test indicates  
2 that the device interface is not one cause of the failure, further performing:  
3 removing the device interface from the suspect list; and  
4 performing a device isolation test of the device.

09772626-013001

Sub A1

1 9. The method of claim 1, wherein performing the isolation testing of the host  
2 adaptor and device interface comprises additional isolation testing of field replaceable units  
3 within the host adaptor and device interface.

1 10. The method of claim 1, further comprising:  
2 determining whether the path components include at least one switch, device port,  
3 initiator port, and links therebetween, wherein the host adaptor connects through a initial link to  
4 an initiator port on the switch and the device interface connects through a second link to a  
5 device port on the switch; and  
6 performing isolation testing on the switch, device port, initiator port, and the first and  
7 second links if the path includes the switch.

1 11. The method of claim 1, further comprising:  
2 receiving input from the user indicating a level of testing, wherein the extent of the  
3 isolation tests are determined by the user indicated testing level.

1 12. The method of claim 1, wherein the device comprises a storage system.

1 13. The method of claim 12, wherein the storage system comprises storage areas,  
2 further comprising:  
3 receiving input from the user indicating storage areas to test in the storage system,  
4 wherein the isolation tests on the storage system are performed with respect to those storage  
5 areas indicated by the user.

1 14. The method of claim 12, wherein the storage system adheres to the Fibre  
2 Channel protocol and architecture and the link comprises an optical fiber wire.

097266-013001

Sub A1

1 15. The method of claim 1, wherein the system is capable of including different  
2 types of host adaptors and device interfaces, wherein there is a separate isolation test for each  
3 of the different types of host adaptors and device interfaces that are capable of being included  
4 in the system, and wherein performing an isolation test with respect to one host adaptor or  
5 device interface comprises:

6 determining a type of the host adaptor or device interface; and  
7 performing the isolation test for the determined type of host adaptor or device interface.

1 16. A system for automatically diagnosing a storage system, comprising:

2 (a) a storage system includes a plurality of path components comprising:

3 (i) a host adaptor;

4 (ii) a link;

5 (iii) a device interface; and

6 (iv) a device; and

7 (b) a processor;

8 (c) a computer readable medium accessible to the processor;

9 (d) a suspect list embedded in the computer readable medium; and

10 (e) a diagnostic software embedded in the computer readable medium capable of

11 causing the processor to perform:

12 (i) performing an initial test to determine if there is a failure in the path;

13 (ii) adding at least one of the path components to the suspect list capable of

14 being a cause of the failure;

15 (iii) performing at least one isolation test on at least one of the path components  
16 added to the suspect list;

17 (iv) removing the tested path component from the suspect list if the isolation test  
18 confirms that the tested path component cannot be a source of the failure; and

09772626-013001

sub A1

19 (v) returning the suspect list to a user to provide information on the path  
20 components capable of being the cause of the failure.

1 17. The system of claim 16, wherein the initial test comprises a test of the path, and  
2 wherein path components are added to the suspect list and isolation tested after the first test  
3 indicates a path failure.

1 18. The system of claim 16, wherein the first test comprises a test of the path, and  
2 wherein path components are added to the suspect list and isolation tested after the first test  
3 indicates no path failure to provide additional testing of the path components.

1 19. The system of claim 16, wherein isolation testing the host adaptor comprises:  
2 generating output to instruct the user to disconnect the host adaptor from the link,  
3 wherein the isolation test is performed on the host adaptor after the user provides input  
4 indicating that the host adaptor was disconnected, wherein the host adaptor is removed from  
5 the suspect list if the host adaptor passes the diagnostic test.

1 20. The system of claim 19, wherein the diagnostic tool software is further capable  
2 of causing the processor to perform:  
3 generating output to instruct the user to replace the link if the host adaptor passes the  
4 test;  
5 performing a link isolation test on the path with the new link; and  
6 removing path components from the suspect list if the link isolation test on the replaced  
7 link indicates that the link was one cause of the failure.

09772626-01.3001

*Sub A1*

1           21.     The system of claim 20, wherein if the link isolation test indicates that the link is  
2 not one cause of the failure, then the diagnostic tool software is further capable of causing the  
3 processor to perform:

4           removing the link from the suspect list;  
5           generating output to instruct the user to reinstall the previously replaced link; and  
6           performing a device interface isolation test of the device interface.

1           22.     The system of claim 21, wherein the diagnostic tool software is further capable  
2 of causing the processor to perform

3           generating output to instruct the user to disconnect the device interface from the link to  
4 allow for isolation testing of the device interface.

1           23.     The system of claim 21, wherein if the device interface isolation test indicates  
2 that the device interface is not one cause of the failure, further performing:

3           removing the device interface from the suspect list; and  
4           performing a device isolation test of the device.

1           24.     The system of claim 16, wherein performing the isolation testing of the host  
2 adaptor and device interface comprises additional isolation testing of field replaceable units  
3 within the host adaptor and device interface.

1           25.     The system of claim 16, wherein the diagnostic tool software is further capable  
2 of causing the processor to perform:

3           determining whether the path components include at least one switch, device port,  
4 initiator port, and links therebetween, wherein the host adaptor connects through a first link to

097266-013001

5 an initiator port on the switch and the device interface connects through a second link to a  
6 device port on the switch; and  
7 performing isolation testing on the switch, device port, initiator port, and the first and  
8 second links if the path includes the switch.

1 26. The system of claim 16, wherein the diagnostic tool software is further capable  
2 of causing the processor to perform:

3 receiving input from the user indicating a level of testing, wherein the extent of the  
4 isolation tests are determined by the user indicated testing level.

1 27. The system of claim 16, wherein the device comprises a storage system.

1 28. The system of claim 27, wherein the storage system comprises storage areas,  
2 wherein the diagnostic tool software is further capable of causing the processor to perform:

3 receiving input from the user indicating storage areas to test in the storage system,  
4 wherein the isolation tests on the storage system are performed with respect to those storage  
5 areas indicated by the user.

1 29. The system of claim 27, wherein the storage system adheres to the Fibre  
2 Channel protocol and architecture and the link comprises an optical fiber wire.

1 30. The system of claim 16, wherein the system is capable of including different  
2 types of host adaptors and device interfaces, wherein there is a separate isolation test for each  
3 of the different types of host adaptors and device interfaces that are capable of being included  
4 in the system, and wherein performing an isolation test with respect to one host adaptor or  
5 device interface comprises:

Sub A1

09773636-01301

Sub A1

6 determining a type of the host adaptor or device interface; and  
7 performing the isolation test for the determined type of host adaptor or device interface.

1 31. An article of manufacture for implementing a diagnostic tool for automatically  
2 diagnosing a system, wherein the diagnostic tool is embedded in a computer readable medium  
3 and includes code capable of causing a processor to perform:  
4 determining a path in the storage system to test, wherein the path includes path  
5 components including at least a host adaptor, a link, a device interface, and a device;  
6 performing an initial test to determine if there is a failure in the path;  
7 adding at least one of the path components to a suspect list capable of being a cause of  
8 the failure, wherein the suspect list is implemented in a computer readable data structure;  
9 performing at least one isolation test on at least one of the path components added to  
10 the suspect list;  
11 removing the tested path component from the suspect list if the isolation test confirms  
12 that the tested path component cannot be a source of the failure; and  
13 returning the suspect list to a user to provide information on the path components  
14 capable of being the cause of the failure.

1 32. The article of manufacture of claim 31, wherein the initial test comprises a test  
2 of the path, and wherein path components are added to the suspect list and isolation tested after  
3 the initial test indicates a path failure.

1 33. The article of manufacture of claim 31, wherein the initial test comprises a test  
2 of the path, and wherein path components are added to the suspect list and isolation tested after  
3 the initial test indicates no path failure to provide additional testing of the path components.

0972626-013004



Pub A1

1 34. The article of manufacture of claim 31, wherein isolation testing the host  
2 adaptor comprises:  
3 generating output to instruct the user to disconnect the host adaptor from the link,  
4 wherein the isolation test is performed on the host adaptor after the user provides input  
5 indicating that the host adaptor was disconnected, and wherein the host adaptor is removed  
6 from the suspect list if the host adaptor passes the diagnostic test.

1 35. The article of manufacture of claim 34, wherein the diagnostic tool code is  
2 further capable of causing the processor to perform:  
3 generating output to instruct the user to replace the link if the host adaptor passes the  
4 test;  
5 performing a link isolation test on the path with the new link; and  
6 removing path components from the suspect list if the link isolation test on the replaced  
7 link indicates that the link was one cause of the failure.

1 36. The article of manufacture of claim 34, wherein if the link isolation test indicates  
2 that the link is not one cause of the failure, and wherein the diagnostic tool code is further  
3 capable of causing the processor to perform:  
4 removing the link from the suspect list;  
5 generating output to instruct the user to reinstall the previously replaced link; and  
6 performing a device interface isolation test of the device interface.

1 37. The article of manufacture of claim 36, wherein the diagnostic tool code is  
2 further capable of causing the processor to perform:  
3 generating output to instruct the user to disconnect the device interface from the link to  
4 allow for isolation testing of the device interface.

0973636-01004

And A1)

1 38. The article of manufacture of claim 36, wherein if the device interface isolation  
2 test indicates that the device interface is not one cause of the failure, further performing:  
3 removing the device interface from the suspect list; and  
4 performing a device isolation test of the device.

1 39. The article of manufacture of claim 31, wherein performing the isolation testing  
2 of the host adaptor and device interface comprises additional isolation testing of field  
3 replaceable units within the host adaptor and device interface.

1 40. The article of manufacture of claim 31, wherein the diagnostic tool code is  
2 further capable of causing the processor to perform:  
3 determining whether the path components include at least one switch, device port,  
4 initiator port, and links therebetween, wherein the host adaptor connects through a initial link to  
5 an initiator port on the switch and the device interface connects through a second link to a  
6 device port on the switch; and  
7 performing isolation testing on the switch, device port, initiator port, and the first and  
8 second links if the path includes the switch.

1 41. The article of manufacture of claim 31, wherein the diagnostic tool code is  
2 further capable of causing the processor to perform:  
3 receiving input from the user indicating a level of testing, wherein the extent of the  
4 isolation tests are determined by the user indicated testing level.

1 42. The article of manufacture of claim 31, wherein the device comprises a storage  
2 system.

0977309035US1

Pub A1

097266-01001

1 43. The article of manufacture of claim 42, wherein the storage system comprises  
2 storage areas, wherein the diagnostic tool code is further capable of causing the processor to  
3 perform:  
4 receiving input from the user indicating storage areas to test in the storage system,  
5 wherein the isolation tests on the storage system are performed with respect to those storage  
6 areas indicated by the user.

1 44. The method of claim 1, wherein the system is capable of including different  
2 types of host adaptors and device interfaces, wherein there is a separate isolation test for each  
3 of the different types of host adaptors and device interfaces that are capable of being included  
4 in the system, and wherein performing an isolation test with respect to one host adaptor or  
5 device interface comprises:  
6 determining a type of the host adaptor or device interface; and  
7 performing the isolation test for the determined type of host adaptor or device interface.

1 45. A computer readable medium including data structures used to perform  
2 diagnostic testing of a system, comprising:  
3 a rule object including code defining a flow of operations to perform diagnostic testing  
4 of a path in the system, wherein the path includes path components including at least a host  
5 adaptor, a link, a device interface, and a device, wherein the rule object calls test descriptors  
6 associated with a testing operation to perform;  
7 a test descriptor object including test descriptors, wherein each test descriptor specifies  
8 one or more program modules to perform the testing operation associated with the test  
9 descriptor; and  
10 a module object including program modules providing code to perform testing  
11 operations, wherein a call to one test descriptor executes the program modules specified by the

DWAI

12 test descriptor to perform diagnostic testing operations according to the operation flow  
13 specified in the rule object.

1 46. The computer readable medium of claim 45, wherein multiple program modules  
2 call at least one library module to perform diagnostic related operations performed within the  
3 multiple program modules.

1 47. The computer readable medium of claim 46, further comprising a suspect list  
2 data structure indicating path components capable of being a source of a failure in the tested  
3 path, wherein the rule object includes code to add path components capable of being a source  
4 of the failure to the suspect list and removes path components from the suspect list that are  
5 determined not to be capable of being the source of the failure..

1 48. The computer readable medium of claim 46, wherein the flow of operations  
2 defined in the rule object comprises:  
3 calling a first test descriptor, wherein the first test descriptor specifies at least one  
4 program module to determine if there is a failure in the path;  
5 adding at least one of the path components to the suspect list that is capable of being a  
6 cause of the failure;  
7 calling at least one isolation test descriptor associated with at least one of the path  
8 components added to the suspect list, wherein the isolation test descriptor specifies at least one  
9 program module to determine if there is a failure in the path component associated with the  
10 called isolation test descriptor;  
11 removing the path component from the suspect list if the isolation test defined by the  
12 called isolation test descriptor confirms that the tested path component cannot be a source of  
13 the failure; and

0972626-013001

- 14 returning the suspect list to a user to provide information on possible failed components
- 15 in the tested path.

**THIS PAGE BLANK (USPTO)**

09772626-013001